ACTA Scientiarum Polonorum
Acta Sci. Pol. Zootechnica 21(1) 2022, 3–10

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2022.21.1.01

ORIGINAL PAPER

Received: 30.01.2022
Accepted: 08.03.2022

THE EFFECT OF FEED SUPPLEMENTATION WITH CU ANG ZN CHELATES ON THE CONTENT OF THESE ELEMENTS IN THE BLOOD OF BROILER CHICKENS AND THEIR BODY WEIGHT AND FEED CONVERSION

Sabina Kaim-Mirowski[1], Barbara Biesiada-Drzazga[1], Katarzyna Andraszek[1], Mohamed Ali Saleh[2], Dorota Banaszewska[1]✉

[1]Siedlce University of Natural Sciences and Humanities, Faculty of Agrobioengineering and Animal Husbandry, Institute of Animal Science and Fisheries, Bolesława Prusa 14, 08-110 Siedlce, Poland
[2]Sohag University, Faculty of Agriculture, Department of Poultry Production, Street Nasser City, 82524, Sohag, Egypt

ABSTRACT

The aim of the study was to determine the effect of Cu and Zn chelates on the levels of these microelements in the blood of broiler chickens in successive weeks of rearing. The research material was Ross 308 broiler chickens. The study was carried out in two buildings with 30,000 chickens in each. From each building, 50 chickens were randomly selected to form the experimental and control groups. Blood for analysis was collected from the wing vein every 7 days, from the first day of fattening to day 42. In the experimental group the microelements zinc and copper contained in the feed were in organic form. The effect of the feed additive containing selected microelements in organic form on broiler chickens was assessed from weeks 1 to 6 of fattening. During the experiment the average body weight gains were monitored. Mortality was monitored, and feed consumption per kg weight gain was estimated. To conclude, the addition of organic Cu and Zn chelates to the diet of broiler chickens affected their average body weight gain, increasing body weight at the start and end of the fattening period (fifth and sixth weeks of age) while increasing feed conversion.

Key words: broiler chicken; chelates; production performance

INTRODUCTION

Poland is a leader in poultry production in the European market. Both growth dynamics and the feed conversion ratio have improved considerably over the years. Feeding chicken broilers is becoming a challenge for all poultry farmers. It is essential to provide sufficient levels of mineral compounds and vitamins to meet the needs of fast-growing birds. For this reason work is conducted to maximize the bioavailability of micro- and macroelements contained in feed. Recent years have seen increased interest in the use of biocomplexes as a source of microelements. Many researchers have asked whether the bioavailability of microelements in a chelate is higher than in inorganic forms. The main microelements that can be used in organic form in the diet of meat chickens include zinc and copper, each of which performs an important role during the growth and development of the bird [Bao et al. 2007].

Zinc takes part in protein, carbohydrate and nucleic acid metabolism and activates enzymes essential to the functioning of the immune system. It also plays a significant role in restoring the layer of keratin, an essential protein in feathers. Zinc is often added to poultry feeds [Bao et al. 2007]. It binds to phytic acid in the intestine, which prevents its absorption. For this reason it is important to maintain an adequate amount of zinc in the diet [Zakaria et al. 2017]. Sources of zinc commonly used in chicken feed can be divided into inorganic sulphates ($ZnSO_4$) and oxides (ZnO) [Tronina et al. 2007]. Bioavailability of zinc is higher in the case of organic

✉ dorota.banaszewska@uph.edu.pl

sources, i.e. amino acid complexes (Zn-AA), than in the case of inorganic forms [Salim et al. 2010]. According to the National Research Council [2005], the optimum zinc content in poultry feed is 40 mg · kg^{-1}, irrespective of the source. Feed formulations contain zinc in amounts of up to even 80 mg · kg^{-1} to achieve maximum bioavailability [Jahanian and Rasouli 2015]. The producer of Ross 308 chicks recommends using 100 mg of zinc per kg of feed [Aviagen broiler ROSS 2019]. However, excessive supplementation with this element leads to contamination of the environment due to its poor utilization. The addition of zinc to feed is justified because a zinc deficiency can inhibit growth, reduce immunity, and cause skin lesions or incomplete plumage [Hajilari et al. 2019].

Copper in the body activates reserves of iron, which is essential to haemoglobin synthesis and production of red blood cells [Makarski et al. 2002]. It is also a component of many tissue enzymes and takes part in metabolic processes, including lipid metabolism [Dmoch and Polonis 2007]. The copper requirement of chickens is 4–10 mg · kg^{-1} body weight [Labier and Leclerq 1995]. The producer of Ross 308 chicks recommends using copper in feed in the amount of 16 mg · kg^{-1} [Aviagen 2009]. Copper deficiencies can interfere with synthesis of plasma proteins such as haemoglobin, erythrocuprein, and ceruloplasmin [Hajilari et al. 2019], manifested as growth and fertility disorders and anaemia [Dmoch and Polonis 2007]. High content of cereals is a factor blocking the efficiency of copper utilization from feed, because cereals contain phytic acids and phytates, which form stable complexes with copper. High viscosity of digesta, as in the case of a high-fibre diet, also does not favour the bioa-vailability of copper [Koreleski 1993, Jamroz and Wertelecki 1999]. The aim of study was to assess the influence of selected micronutrients in the form of organic compounds in the diet of broiler chickens on selected blood biochemical indicators, body weight and feed conversion ratio.

MATERIAL AND METHODS

The research material was Ross 308 broiler chickens. The study was carried out in two buildings with 30,000 chickens in each. The birds were kept in a barn system in accordance with accepted standards for rearing broiler chickens and the recommendations of the broiler chick producer [Aviagen 2018]. The microclimate conditions in the two buildings were very similar. The relative humidity ranged from 60 to 70%. The temperature was adjusted to the age of the birds and rearing recommendations. Feed and drinking water were provided *ad libitum*. From each building, 50 chickens were randomly selected to form the experimental and control groups. Wing bands were used for identification of the selected birds. To facilitate identification, the birds chosen for the study were separated by a tem-porary enclosure from the remaining birds. Blood for analysis was collected from the wing vein every 7 days, from the first day of rearing to day 42.

In the experimental group, for the first 10 days of life the birds received starter feed in crumble form. The levels of zinc and copper in the feed were established according to nutritional standards (zinc min. 100 mg · kg^{-1} feed, copper min. 16 mg · kg^{-1} feed for the entire rearing period [Aviagen broiler ROSS 2019]. The microelements zinc and copper in the feed were in organic (chelated) form. The feed contained Zn in the amount of 123.66 mg · kg^{-1} and Cu in the amount of 25.45 mg · kg^{-1}. The feed was adjusted to the requirements and age of the birds. From days 10–24 the birds received Grower feed produced on-farm (with elements in organic form, as glycine chelates: Cu 24.940 mg · kg^{-1} and Zn 121.554 mg · kg^{-1}). Finisher feed (with elements in organic form, as glycine chelates: Cu 14.346 mg · kg^{-1} and Zn 44.624 mg · kg^{-1}) was used from days 25 to 42. In the control group, for the first 10 days the birds received starter feed in crumble form. The microelements contained in the feed were Zn in the amount of 113.67 mg · kg^{-1} and Cu in the amount of 20.44 mg · kg^{-1}. The feed was adjusted to the requirements and age of the birds. The Grower feed contained Cu in the amount of 19.931 mg · kg^{-1} and Zn in the amount of 111.567 mg · kg^{-1} in sulphate form. Finisher feed contained 9.338 mg · kg^{-1} Cu and 34.637 mg · kg^{-1} Zn in sulphate form. These levels of trace elements resulted from their content in the feedstuffs and a mineral and vitamin additive. The ingredient composition and analysis of the diets are presented in Table 1. Serum obtained by centrifuging blood samples for 4 min at 3000 rpm (MPW 341, Poland) was used for the analyses. A pipette was used to transfer the serum to a separate test tube, which was frozen at –20°C. Minerals were assayed by ICP emission spectrometry. During the experiment the average body weight gains were monitored by weighing the selected individuals once a week. Mortality was monitored, and feed consumption per kg weight gain was estimated. The effect of the feed additive containing selected microelements in organic form on broiler chickens was assessed from weeks 1 to 6 of rearing. The body weight of the birds was determined by calculating the average from weighing on days 7, 14, 21, 28, 35 and 42 of fattening.

Statistical differences between the samples were tested using Tukey's test and ANOVA (STATISTICA version 10.0, StatSoft Inc., PL). The level of significance was set at $P \leq 0.05$.

RESULTS

Table 2 presents data on the content of minerals in the serum of broiler chickens from the control group and the

Table 1. Ingredients and analytical constituents of feeds used in the diet of Ross 308 broiler chickens

Ingredient	Starter 0–10 days of life		Grower 11–24 days of life		Finisher 25–42 days of life	
	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group
Maize (%)	15	15	11.5	11.5	15	15
Soybean meal (%)	34.9	34.9	29.7	29.7	26.2	26.2
Calcium carbonate (%)	1.45	1.45	1.08	1	1.02	1.02
Sodium bicarbonate (%)	0.15	0.15	0.18	0.18	0.19	0.19
Salt (%)	0.25	0.25	0.19	0.19	0.2	0.2
Monocalcium phosphate (%)	0.95	0.95	0.71	0.71	0.55	0.55
Soybean oil (%)	3.1	3.1	0	0	0	0
Methionine (%)	0.31	0.31	0.31	0.31	0.22	0.22
Lysine (%)	0.19	0.19	0.3	0.3	0.23	0.23
Wheat (%)	43.3	43.2	51.7	51.6	51.5	51.4
0.4% mineral and vitamin premix (%)	0.4	0.4	0.4	0.4	0.4	0.4
PA 859-Chelatos – feed additive (%)	–	0.1	–	0.1	–	0.1
Lard (%)	–	–	3.8	3.8	4.4	4.4
Threonine (%)	0.1	0.1	0.13	0.13	0.9	0.9
Analytical constituents						
ME (kcal per kg)	2995.12	2991.95	3 079.007	3 075.839	3 162.070	3 158.902
Fat (%)	4.82	4.82	5.400	5.399	6.104	6.102
Crude protein (%)	22.51	22.5	21.010	21.004	19.548	19.543
Methionine (%)	0.64	0.64	0.613	0.613	0.508	0.508
Methionine +cystine (%)	1.03	1.03	0.985	0.984	0.863	0.863
Lysine (%)	1.33	1.33	1.285	1.285	1.139	1.138
Tryptophan (%)	0.28	0.28	0.255	0.255	0.236	0.236
Threonine (%)	0.82	0.82	0.878	0.878	0.787	0.786
Digestible methionine (%)	0.61	0.61	0.584	0.583	0.480	0.480
Digestible methionine +cystine (%)	0.94	0.94	0.902	0.901	0.784	0.784
Digestible lysine (%)	1.19	1.19	1.158	1.157	1.021	1.020
Digestible threonine (%)	0.71	0.71	0.771	0.771	0.686	0.686
Digestible tryptophan (%)	0.24	0.24	0.221	0.221	0.205	0.205
Ash (%)	6.01	6.1	5.150	5.237	4.796	4.883
Calcium (%)	1.11	1.14	0.909	0.942	0.811	0.844
Total phosphorus (%)	0.59	0.59	0.523	0.523	0.474	0.474
Available phosphorus (%)	0.48	0.48	0.431	0.431	0.367	0.367
Cu (mg per kg)	20.44	25.45	19.931	24.940	9.338	14.364
Zn (mg per kg)	113.67	123.66	111.567	121.554	34.637	44.624
Na (%)	0.15	0.15	0.135	0.135	0.137	0.137
Cl (%)	0.23	0.23	0.221	0.221	0.213	0.213
Moisture (%)	12	11.99	11.918	11.906	11.890	11.873
Vitamin A (K UI)	9.000	9.000	9.000	9.000	9.000	9.000
Vitamin D_3 (K UI)	5.000	5.000	5.000	5.000	5.000	5.000
Vitamin E (mg)	22.000	22.000	22.000	22.000	22.000	22.000

experimental group receiving copper and zinc chelates in their feed. The Cu content in the serum of the birds in the experimental group was shown to be higher in all weeks of the study, except for week 5. The addition of Cu in chelated form significantly increased the level of this element in weeks 1, 2 and 6 of rearing ($P \leq 0.05$). In the case of the addition of a Zn chelate, apart from weeks 3 and 4, the serum level of Zn was lower. At this age, however, no statistical differences were confirmed between the control and experimental groups. In the final weeks of fattening, serum Zn levels were 0.29 mg $\cdot$ L^{-1} higher in the birds from the control group than in the experimental group ($P \leq 0.05$).

Table 3 presents the growth performance of broiler chickens in the control and experimental groups. In the initial and final stage of fattening, i.e. weeks 1, 5 and 6, the birds in the experimental group had higher body weight than in the control group. During the experiment

Table 2. Content of minerals in the serum of broiler chickens from the control group and experimental group receiving feed supplemented with copper and zinc chelates

Mineral	Age (week of life)	Control group	Experimental group
Cu (mg per Liter)	0	0.059[a] ±0.008	0.059[a] ±0.008
	1	0.106[a] ±0.012	0.117[b] ±0.016
	2	0.106[a] ±0.013	0.120[b] ±0.019
	3	0.138[a] ±0.019	0.160[a] ±0.027
	4	0.134[a] ±0.006	0.137[a] ±0.009
	5	0.133[a] ±0.011	0.125[a] ±0.008
	6	0.104[a] ±0.025	0.126[b] ±0.031
Zn (mg per Liter)	0	1.60[a] ±0.08	1.60[a] ±0.08
	1	1.91[a] ±0.10	1.89[a] ±0.10
	2	1.73[a] ±0.11	1.74[a] ±0.09
	3	1.51[a] ±0.09	1.61[b] ±0.12
	4	1.72[a] ±0.13	1.78[a] ±0.14
	5	1.46[a] ±0.12	1.33[b] ±0.15
	6	1.72[a] ±0.14	1.43[b] ±0.16

Means in rows with lowercase superscript letters a, b are significantly different at $P \le 0.05$.

the feed conversion ratio was estimated for both groups (Table 3). The addition of chelates was shown to increase the feed conversion ratio in the experimental group, but statistical differences were confirmed only in week 4. The increase in the feed conversion ratio in the experimental group in comparison with the control group persisted to the end of the fattening period, in every week of fattening ($P \leq 0.05$).

The data in Table 4 indicate that the chickens in the experimental group had slightly higher mortality (0.01–0.06%), but the difference was statistically confirmed only in the first week of fattening.

DISCUSSION

The use of trace elements in the form of chelates in the diet of poultry continues to be the subject of many studies [Wang et al. 2007, Vieira 2008]. Not all elements can be chelated. The ones used in this form are cobalt, copper, manganese, zinc and iron, as regulated by the European Union in Directive 1334/2003 [Biesek 2018]. According to Männer et al. [2006], the stability and availability of intestinal chelates based on the smallest amino acid, i.e. glycine, is 25% higher than in lysine or methionine chelates. The addition of bioavailable minerals to feed has a positive effect on bone development in birds and the functioning of the body [Kwiatkowska et al. 2018]. The mechanism of action of chelates is still not entirely clear. Some authors suggest that elements may be absorbed unchanged through the intestinal mucosa owing to an amine group (the amino acid transport system), and for this reason are better absorbed [Yan and Waldroup 2006, Wang et al. 2007, Vieira 2008]. However, some studies, indicate that the diet of broiler chickens has high content of certain elements. A study by Kwiatkowska et al. [2017] analysing the production performance of chicken broilers and the morphometric and strength parameters of their tibias showed that the intake of Fe (40 mg · kg^{-1} feed) recommended by broiler chicken producers is two or even four times too high. The higher bioavailability of chelated minerals is believed to be due to the fact that they are bound to an amino acid, which prevents the formation of complexes with antinutritional substances [Ettle et al. 2008]. Kwiecień et al. [2015a] and Kwiatkowska et al. [2018] recommend caution in using a large amount of Fe-glycinate chelate. Administration of appropriate amounts of Fe in bioavailable forms protects against anaemia and its negative effects [Yu et al. 2000]. The positive effects of Fe-Gly on the health of not only animals but humans as well is confirmed in research by many authors [Pineda and Ashmead 2001, Mazariegos et al. 2004, Fuchs et al. 2009]. However, excessive intake of iron relative to needs may inhibit absorption of zinc [National Research Council 2005]. The concentration of Zn has a tendency to increase when iron is added to feed, while increased availability of zinc can positively influence the concentration of erythropoietin, which is responsible for stimulating erythropoiesis [Konomi and Yokoi 2005]. The addition of a Zn chelate also affects bone tissue by stimulating osteo-blasts and weakening or inhibiting the activity of osteoclasts. This is particularly important in the case of the tibia, which is susceptible to damage and deformation during rapid growth [Kwiatkowska et al. 2016]. Supplementation with Zn-Gly has been shown to increase the body's antioxidant capacity and storage of zinc in the liver of chickens, but it did not affect body weight gains in broiler chickens [Kwiecień et al. 2017]. Kwiecień et al. [2014] and Winiarska-Mieczan and Kwiecień [2015] showed that the addition of Gly-Cu to feed for broiler

Table 3. Performance parameters of broiler chickens in the control and experimental groups

Parameter	Age (week of life)	Control group	Experimental group
Body weight (kg)	1	0.182[a] ±0.009	0.188[b] ±0.011
	2	0.445[a] ±0.011	0.442[a] ±0.012
	3	0.770[a] ±0.015	0.710[a] ±0.020
	4	1.380[a] ±0.047	1.380[a] ±0.026
	5	1.650[a] ±0.198	1.740[b] ±0.093
	6	2.590[a] ±0.205	2.660[b] ±0.199
Feed conversion (kg)	1	0.80[a] ±0.10	1.87[a] ±0.13
	2	1.57[a] ±0.06	1.50[a] ±0.09
	3	1.30[a] ±0.09	1.43[a] ±0.12
	4	1.34[a] ±0.11	1.45[b] ±0.12
	5	1.69[a] ±0.12	1.70[b] ±0.15
	6	1.72[a] ±0.14	1.74[b] ±0.16

Means in rows with lowercase superscript letters a, b are significantly different at $P \leq 0.05$.

Table 4. Mortality of chickens in each week of rearing.

Age (week of life)	Control group		Experimental group	
	Number	%	Number	%
1	40.29[a] ±14.21	0.13[a] ±0.05	58.14[b] ±35.34	0.19[b] ±0.12
2	20.00[a] ±2.77	0.07[a] ±0.01	23.00[a] ±6.06	0.08[a] ±0.02
3	16.43[a] ±7.16	0.05[a] ±0.02	20.71[a] ±18.99	0.07[a] ±0.06
4	11.57[a] ±3.55	0.04[a] ±0.01	15.57[a] ±5.38	0.05[a] ±0.02
5	13.86[a] ±4.74	0.05[a] ±0.02	15.86[a] ±10.62	0.05[a] ±0.04
6	11.14[a] ±4.88	0.04[a] ±0.02	13.57[a] ±6.58	0.06[a] ±0.03

Means in rows with lowercase superscript letters a, b are significantly different at $P \leq 0.05$.

chickens has a beneficial effect on their growth and development. Kwiatkowska et al. [2016] found that the use of Cu-Gly increased bone strength parameters, and chelated Cu in the form of Cu-Gly en-sured proper bone mineralization, even in smaller amounts than those recommended for fast-growing broilers. According to Kwiatkowska et al. [2016], the addition of 16 mg of Cu-Gly increased the Ca level in the bones of broiler chickens. In contrast, research by Dmoch and Polonis [2007] showed that the use of a Cu-Lys chelate reduced the plasma Ca level, which may be linked to the dynamics of skeletal system development in growing birds; during mineralization of the skeleton, essential elements are taken from the blood. The use of these compounds improves absorption of essential minerals, and birds absorb the organic part at the same time [Biesek 2018]. The present study showed differences in Cu content in chickens at the beginning and end of the rearing period, and in Zn content mainly in the final week. However, the relationships were reversed: the Cu level was higher in the experimental group, while the Zn level was higher in the control group. The elevated level of copper in the serum of the broilers in the experimental group indicates that the Gly-Cu chelate is better absorbed at the level of the gut-blood barrier. The results suggest that an elevated copper level in the blood stimulates feed intake but reduces its conversion. Higher feed intake is also linked to a faster growth rate in chickens and unexpected weight gain in a short time. The level of zinc was higher in the control group, which indicates that the organic form Gly-Zn was less easily absorbed. The results suggest that raising the level of zinc in feed does not improve growth parameters. Zinc in oxide form was better absorbed.

Trace elements such as Cu are essential for the growth and development of chickens, and owing to their microbiological properties they have a positive effect on processes taking place in the gastrointestinal tract [Abdallah et al. 2009, Kuźlik-Wyrostek and Makarski 2009], which in turn improves body weight and meat quality [Pesti and Bakalii 1996, Wang et al. 2008]. In research by Kwiecień et al. [2015b], the use of an organic form of Cu did not reduce the content of minerals in the livers of chickens, and the biochemical and haematological parameters of the blood remained normal. Studies by many authors indicate that supplementation with Cu in organic form decreases crude protein levels in the liver of birds [Makarski and Zadura 2006, Wang et al. 2007]. Wedekind et al. [1992] reported that Cu chelates are absorbed from the intestine more effectively than Cu in inorganic form. Kim et al. [2011] suggest that chelates can be potential substitutes for antibiotics, as they cause an increase in the population of lactic acid bacteria while decreasing that of *E. coli* in the intestine. Furthermore, organic forms of microelements have been shown to protect against gastrointestinal disorders during transport and do not cause deactivation of C, E or B vitamins, whose reduced effect may result in stress, poor growth performance, poorer meat quality, a lower feed conversion ratio, and higher mortality [Biesek 2018]. Cu in organic form is believed to affect lipid metabolism in animals. Winiarska-Mieczan and Kwiecień [2015] found that cholesterol content in the meat of chickens receiving chelated Cu was lower than in the meat of chickens receiving Cu in sulphate form. Kwiecień et al. [2015b] reported that the addition of Cu-Gly to feed significantly reduced the level of total cholesterol, which may indicate a positive effect on the breakdown and oxidation of fatty acids. Other authors [Makarski et al. 2006, Mondal et al. 2007, Aksu et al. 2010] have reported similar observations of reduced cholesterol in the plasma of broiler chickens following the addition of Cu to the diet. The positive effect of Cu in organic form is confirmed in research by many authors [Aoyagi and Baker 1993]. Furthermore, the addition of an organic form of Cu leads to better utilization of this element by animals, thus decreasing the amount of Cu in the droppings and thereby reducing the negative effect on the environment [Nollet et al. 2007, Kwiecień et al. 2015b]. Consumption of poultry meat pro-duced using a Cu supplement may be an alternative to Cu supplements recommended for maintaining adequate levels in the human diet [Hordyjewska and Pasternak 2011].

CONCLUSIONS

To conclude, the addition of organic Cu and Zn chelates to the diet of broiler chickens affected their weight gain, increasing body weight at the start and end of the rearing period (fifth and sixth weeks of age) while increasing feed conversion. The continuous advances in genetic improvement of chickens necessitate further research aimed at updating and balancing feed rations supplemented with chelates. The low level of zinc in the blood of chickens in the experimental group, accompanied by a higher level of copper, may indicate that zinc does not significantly influence weight gains in chickens. However, the increased copper level in the blood of chickens in the experimental group may indicate stimulation of weight gain and increased appetite, but with poorer feed conversion. The blood parameters confirm the high bioavailability of biocomplexes. The copper level in the blood was significantly different between groups. The zinc level was higher in the control group, which may suggest that copper and zinc in the form of glycine chelates have antagonistic effects, which cannot be said of the use of these elements in inorganic forms.

REFERENCES

Abdallah, A.G., El-Husseiny, O.M., Abdel-Latif, K.O. (2009). Influence of Some Dietary Organic Mineral Supplementations on Broiler Performance. J. Poult. Sci., 8(3), 291–298. DOI: 10.3923/ijps.2009.291.298.

Aksu, D.S., Aksu, T., Őzsoy, B. (2010). The effects of lower supplementation levels of organically complexed minerals (zinc, copper and manganese) versus inorganic forms on hematological and biochemical parameters in broilers. Kafkas Universitesi Veteriner Fakultesi Dergisi, 16, 553–559.

Aviagen (2009). Appendix. Page 93 in Ross Broiler Management Manual. Aviagen, Huntsville, AL.

Aviagen (2018). Pocket Guide. Aviagen.

Aviagen broiler ROSS (2019). Nutrition Specifications. Aviagen, Huntsville, AL.

Aoyagi, S., Baker, D.H. (1993). Nutritional evaluation of copper-lysine and zinc-lysine complexes for chickens. Poultry Sci., 72, 165–171. DOI: 10.3382/ps.0720165.

Bao, Y.M., Chock, M., Iji, P.A., Bureton, K. (2007). Effect of organically complexed cooper, iron, manganese, and zinc on broiler performance, mineral excretion, and accumulation of tissues. J. Appl. Polutry Res., 16(3), 448–455. DOI: 10.1093/japr/16.3.448.

Biesek, J. (2018). Chelaty i ich wpływ na występowanie FPD [Chelates and their effect on the occurrence of FPD]. Hodowca Drobiu, 3, 30–34 [in Polish].

Dmoch, M., Polonis, A. (2007). Wpływ biokompleksu miedziowego na wybrane wskaźniki hematologiczne, biochemiczne i zawartość składników mineralnych we krwi kurcząt brojlerów. [Influence of biopleks-cu on hematologicaland biochemical indices and content of mineral components in blood of chicken broilers]. Acta Sci. Pol., Zootechnica, 6(3), 11–18 [in Polish].

Ettle, T., Schlegel, P., Roth, X. (2008). Investigations on iron bioavailability of different sources and supply levels in piglets. J. Anim. Physiol. Anim. Nutr., 92(1), 30–45.

Fuchs, B., Kubizna, J., Szuba-Trznadel, A. (2009). Żywienie tuczników mieszankami treściwymi z udziałem mineralnych i organicznych form mikroelementów Cu, Zn, Mn i Fe [Feeding of fattening pigs with the concentrate mixtures containing mineral and organic forms of Cu, Zn, Mn and Fe]. Zeszyty Naukowe Uniwersytetu Przyrodniczego we Wrocławiu, 59, 87–100 [in Polish].

Hordyjewska, A., Pasternak, K. (2011). Miedź. In: Jackowska I. Pierwiastki w środowisku i medycynie. [Copper. In: Jackowska I. Elements in the environment and medicine]. Wyd. Instytut Naukowo-Wydawniczy SPATIUM, 415–432 [in Polish].

Jahanian, R., Rasouli, E. (2015). Effects of dietary substitution of zinc-methionine for inorganic zinc sources on growth performance, tissue zinc accumulation and some blood parameters in broiler chicks. J. Animal Physiol. Animal Nature, 99(1), 50–58. DOI: 10.1111/jpn.12213.

Hajilari, D., Shams Shargh, M., Ashayerizadeh, O. (2019). Effects of dietary organic and inorganic zinc and cooper supplements on performance, foodpad dermatitis, carcass characteristics, and blood profile of broiler chickens. Poultry Sci. J., 7(1), 15–23.

Kim, G.B., Seo, Y.M., Shin, K.S., Rhee, A.R., Han, J., Paik, I.K. (2011). Effects of supplemental copper-methionine chelate and copper-soy proteinate on the performance, blood parameters, liver mineral content, and intestinal microflora of broiler chickens. J. Appl. Poult. Res., 20, 21–32. DOI: 10.3382/japr.2010-00177.

Konomi, A., Yokoi, K. (2005). Zinc deficiency decreases plasma erythropoietin concentration in rats. Biological Trace Element Research, 107, 289–292. DOI: 10.1385/BTER:107:3:289.

Koreleski, J. (1993). Antyżywieniowe działanie substancji podporowych roślin w żywieniu drobiu. [The antinutritional effect of substances of plant origin in poultry nutrition]. Polskie Drobiarstwo, 11, 4–6 [in Polish].

Kwiatkowska, K., Kwiecień, M., Winiarska-Mieczan, A., Bąkowski, M. (2016). The effect of copper glycine chelate on physicochemical, morphometric and strength parameters of tibia bones in broiler chickens. Annales UMCS, Zootechnica, XXXIV(1), 1–14.

Kwiatkowska, K., Winiarska-Mieczan, A., Kwiecień, M. (2017). Feed additives stimulating calcium absorption in the bones of poultry – a review. Ann. Anim. Sci., 17(2), 303–316. DOI: 10.1515/aoas-2016-0031.

Kwiatkowska, K., Winiarska-Mieczan, A., Kwiecień, M. (2018). Effect of Application of Fe-Glycinate Chelate in Diet for Broiler Chickens in an Amount Covering 50 or 25% of the Requirement on Physical, Morphometric and Strength Parameters of Tibia Bones. Biol. Treace Elem. Res., 184, 483–490. DOI: 10.1007/s12011-017-1171-3.

Kwiecień, M., Winiarska-Mieczan, A., Zawiślak, K., Sroka, S. (2014). Effect of copper glycinate chelate on biomechanical, morpho-metric and chemical properties of chicken femur. Annals of Animal Science, 14, 127–139. DOI: 10.2478/aoas-2013-0085.

Kwiecień, M., Samolińska, W., Bujanowicz-Haraś, B. (2015a). Effects of iron-glycine chelate on growth, carcass characteristic, liver mineral concentrations and haematological and biochemical blood parameters in broilers. J. Anim. Physiol. Anim. Nutr. (Berl), 99(6), 1184–96. DOI: 10.1111/jpn.12322.

Kwiecień, M., Winiarska-Mieczan, A., Piedra, J.V., Bujanowicz-Haraś, B., Chałabis-Mazurek, A. (2015b). Effects of copper glycine chelate on liver and faecal mineral concentrations, and blood parameters in broilers. Agricultural and Food Science, 24, 92–103. DOI: 10.23986/afsci.49511.

Kwiecień, M., Winiarska-Mieczan, A., Milczarek, A., Klebaniuk, R. (2017). Biological Response of Broiler Chickens to Decreasing Dietary Inclusion Levels of Zinc Glycine Chelate. Biol. Trace. Elem. Res., 175, 204–213. DOI: 10.1007/s12011-016-0743-y.

Kuźlik-Wyrostek, M., Makarski, B. (2009). Effect of Cu and lactic acid on hematological and biochemical blond indices and on modification of microbial flora in the gastrointestinal tract of turkeys. J. Elem., 14(3), 53.

Jamroz, D., Wertelecki, T. (1999). Stosowanie enzymów paszowych w mieszankach treściwych zawierających podwyższoną ilość jęczmienia i śruty rzepakowej, przeznaczonych dla kurcząt rzeźnych [The use of feed enzymes in concentrate feeds containing increased amounts of barley and rapeseed meal for meat chickens]. Polskie Drobiarstwo, 3, 5–8 [in Polish].

Labier, M., Leclerq, B. (1995). Żywienie Drobiu [Polutry Nutrition]. PWN Warszawa [in Polish].

Makarski, B.,Polonis, A., Czech, A., Sembratowicz, I. (2002). Wpływ miedzi pochodzącej ze związków nieorganicznych i chelatów na wskaźniki krwi i wyniki produkcyjne indyków [The effect of copper from inorganic compounds and chelates on the blood parameters and growth performance of turkeys]. Ann UMCS, sec. EE, 20(41), 287–293 [in Polish].

Makarski, B., Zadura, A. (2006). Wpływ chelatu miedzi z lizyną na poziom składników hematologicznych i biochemicznych krwi indyków [Influence of copper and lysine chelate on hematological and biochemical component levels in turkey blood]. Annales Universitatis Mariae Curie-Skłodowska (sectio EE), 48, 357–363 [in Polish].

Makarski, B., Zadura, A., Kwiecień, M. (2006). The effect of Cu-Lysine chelate in turkeys diets on the results of slaughter analysis, chemical composition and the fatty acids profile in tissues. Acta Sci. Pol., Zootechnica, 5(2), 57–66.

Mazariegos, D.I., Pizarro, F., Olivares, M., Nuńez, M.T., Arredondo, M. (2004). The mechanisms for regulating absorption of Fe bis-glycine chelate and Fe-ascorbate in Caco-2 cells are similar. J. Nutr., 134, 395–398. DOI: 10.1093/jn/134.2.395.

Männer, K., Simon, O., Schlegel, P. (2006). Effects of different iron, manganese, zinc and copper sources (sulfates, chelates, glycinates) on their bioavailability in early weaned piglets. In: M. Rodehutscord (ed.) Tagung Schweine- und Geflügelernährung. Martin Luther Universität Halle-Wittenberg, Halle, Germany, 25–27.

Mondal, M.K., Das, T.K., Biswas, P., Samanta, C.C., Bairagy, B. (2007). Influence of dietary inorganic and organic copper salt and level of soybean oil on plasma lipids, metabolites and mineral balance of broiler chickens. Animal Feed Science and Technology, 139, 212–233. DOI: 10.1016/j.anifeedsci.2007.01.014.

National Research Council (2005). Mineral Tolerance of Animals. Committee on Minerals and Toxic Substances in Diets and Water for Animals, 2nd revised edition. The National Academies Press, Washington, DC.

Nollet, L., van der Klis, J.D., Lensing, M., Spring, P. (2007). The effect of replacing inorganic with organic trace minerals in broiler diets on productive performance and mineral excretion. J. Appl. Poult. Res., 16, 592–597. DOI: 10.3382/japr.2006-00115.

Pesti, G.M., Bakalii, R.I. (1996). Studies on the feeding of cupric sulfate pentahydrate and cupric citrate to broiler chickens. Poult Sci., 75, 1086–1091. DOI: 10.3382/ps.0751086.

Pineda, O., Ashmead, H.D. (2001). Effectiveness of treatment of iron deficiency anemia in infants and young children with ferrous bisglycinate chelate. Nutrition, 17, 381–384. DOI: 10.1016/S0899-9007(01)00519-6.

Salim, H.M., Lee, H.R., Jo, C., Lee, S.K., Lee, B.D. (2010). Effect of sources and levels of zinc on the tissue mineral concetration and carcass quality of broilers. Avian Biological Research, 3(1), 23–29. DOI: 10.3184/175815510X12636595095213.

Tronina,W., Kinal, S., Lubojemska, B. (2007). Effect of varoius forms of zinc applied concentrate mixtures for broiler chickens on its bio availability as well as maet composition and quality. Pol. J. Food Nutr. Sci., 57(4), 577–581.

Yan, F., Waldroup, P.W. (2006). Evaluation of MINTREX® manganese as a source of manganese for young broilers. Int. J. Poult. Sci., 5, 708–713. DOI: 10.3923/ijps.2006.708.713.

Yu, B., Huang, W.J., Chiou, P.W. (2000). Bioavailability of iron from amino acid complex in weaning pigs. Animal Feed Science and Technology, 86, 39–52. DOI: 10.1016/S0377-8401(00)00154-1.

Wang, Z., Cerrate, S., Coto, C., Yan, F., Waldroup, P.W. (2007). Evaluation of MINTREX® copper as a source of copper in broiler diets. Int. J. Poult. Sci., 6(5), 308–313. DOI: 10.3923/ijps.2007.308.313.

Wang, Z., Cerrate, S., Yan, F., Sacakli, P., Waldroup, P.W. (2008). Comparison of Different Concentrations of Inorganic Trace Minerals in Broiler Diets on Live Performance and Mineral Exeretion. Int. J. Poult. Sci., 7(7), 625–629. DOI: 10.3923/ijps.2008.625.629.

Wedekind, K.J., Hortin, A.E., Baker, D.H. (1992). Methodology for assessing zinc bioavailability: Efficacy es-timates for zinc-methionine, zinc sulfate, and zinc oxide. J. Anim. Sci., 70, 178–187. DOI: 10.2527/1992.701178x.

Winiarska-Mieczan, A., Kwiecień, M. (2015). The effects of copper-glycine complexes on chemical composition and sensory attri-butes of raw, cooked and grilled chicken meat. J. Food Sci. Technol., 52(7), 4226–4235. DOI: 10.1007/s13197-014-1510-8.

Vieira, S.L. (2008). Chelated minerals for poultry. Rev. Bras. Cienc. Avic., 10(2), 73–79. DOI: 10.1590/S1516-635X2008000200001.

Zakaria, HA., Jalal, M., AL.-Titi, HH., Souad A. (2017). Effect of sources and levels of Dietary Zinc on the Performance, Carcass Traits and Blood Parameters of Broilers. Braz. J. Polutry Sci., 19(3), 519–526. DOI: 10.1590/1806-9061-2016-0415.

WPŁYW DODATKU CHELATÓW CU I ZN NA ZAWARTOŚĆ TYCH PIERWIASTKÓW W KRWI KURCZĄT BROJLERÓW ORAZ NA ICH MASĘ CIAŁA I KONWERSJĘ PASZY

STRESZCZENIE

Celem pracy było określenie wpływu chelatów Cu i Zn na poziom tych mikroelementów we krwi kurcząt brojlerów w kolejnych tygodniach odchowu. Materiał do badań stanowiły kurczęta brojlery Ross 308. Badania przeprowadzono w dwóch budynkach po 30 000 kurcząt w każdym. Z każdego budynku wybrano losowo 50 kurcząt do grupy doświadczalnej i kontrolnej. Krew do analizy pobierano z żyły skrzydłowej co 7 dni, od pierwszego dnia odchowu do dnia 42. W grupie doświadczalnej mikroelementy cynk i miedź zawarte w paszy były w formie organicznej. Wpływ dodatku paszowego zawierającego wybrane mikroelementy w postaci organicznej na kurczęta brojlery oceniano od 1 do 6 tygodnia odchowu. Podczas eksperymentu monitorowano średnie przyrosty masy ciała. Monitorowano śmiertelność i oszacowano zużycie paszy na kg przyrostu masy. Podsumowując, dodanie organicznych chelatów Cu i Zn do diety kurcząt brojlerów wpłynęło na ich przyrost masy ciała, zwiększając masę ciała na początku i na końcu okresu odchowu (piąty i szósty tydzień życia) przy jednoczesnym zwiększeniu wykorzystania paszy.

Słowa kluczowe: kurczęta brojlery, chelaty, wydajność produkcji

Sabina Kaim-Mirowski https://orcid.org/0000-0002-8015-0337
Barbara Biesiada-Drzazga https://orcid.org/0000-0002-6748-1932
Katarzyna Andraszek https://orcid.org/0000-0001-5920-4102
Mohamed Ali Saleh https://orcid.org/0000-0002-9300-1357
Dorota Banaszewska https://orcid.org/0000-0002-9894-8590